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Determining the Economic Feasibility of Converting Center Pivot Irrigation Systems from High Pressure to Low Pressure

by

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I. Introduction

Converting center pivot irrigation systems to lower pressure nozzling packages is one method some irrigators can use to reduce energy costs. Several factors must be considered in determining whether the conversion is economically and agronomically feasible. The agronomic and engineering factors are discussed in University of Minnesota Center Pivot Selection Folder no. 444[1/]. This worksheet describes a method of considering the relevant factors to estimate the economic feasibility of a proposed investment in low pressure irrigation.

The factors that must be considered in determining the profitability of converting to low pressure irrigation include the investment cost, the annual energy savings expected over the life of the investment, the expected life of the investment, and the individual's marginal tax rate. The worksheet serves as an aid in calculating the investment required for the conversion and the expected savings in energy costs. The period over which the project should be evaluated is the shorter of the expected physical life and the time at which the system can be expected to be obsolete. Although the physical investment will typically last longer, the possibility of innovations making the system obsolete warrant limiting consideration of energy savings to the five year period considered in this study. The farmers' tax payments may be affected by the investment. Deductions permitted for the investment reduce taxes, while energy savings increase net income which increases taxes. The effect of income taxes on the after-tax investment cost and savings in energy cost are considered in the worksheet[2/].

Internal Revenue Service regulations previously have required that capital expenditures for major equipment modifications, such as conversion from high to low pressure irrigation, be depreciated over their expected useful life. Beginning in 1982 farmers are permitted to deduct a maximum of $5000 annually in capital expenditures for personal property[3/]. This direct expensing option is in place of depreciation and investment credit for property a farmer elects to deduct in this manner. Thus an individual investing in conversion from high to low pressure irrigation can either take investment credit and depreciate the conversion cost over five years, or use the direct expensing option to recover the investment in the conversion. This paper considers both options.

The rate of return after taxes[4/] is the measure of profitability used in the analysis. This can be thought of as the rate earned annually on the investment required to convert to low pressure through reduction in after-tax operating costs.

Many of the time consuming calculations required have been completed and tabulated for use. Section II of the worksheet provides a format for calculating the expected first-year energy savings from a conversion to low pressure irrigation. The escalation of energy costs from year to year influences the potential profitability of an investment in low pressure conversion and must be taken into account.

Two assumptions are made in this paper about energy cost increases. Tables 4 and 6 assume that energy costs escalate at a rate of 8 percent per year. If the general inflation rate is also 8 percent then the real cost of energy remains nearly constant under this assumption. Tables 5 and 7 assume that energy costs rise at a rate of 11 percent per year resulting in a real increase of about 3 percent when the general inflation rate is 8 percent. Many predictions of the general rate of inflation for the next several years are in the range of 8 percent. The Minnesota Energy Agency (MEA) is predicting that the real price of electricity will remain constant from 1981 to 2000[5/]. The MEA also predicts a real gasoline price increase of 2.5 to 3.5 percent per year from 1981 to 2000. Thus nominal rates of increase in energy costs of 8 and 11 percent bracket these estimates.

Section III aids in estimating the investment required to convert to a low pressure system. Calculating the ratio of investment cost to first-year energy savings is discussed in Section IV. The calculated ratio is compared to tabulated ratios to determine the rate of return that can be expected if the conversion is made. The tabulated values assume that the farmer uses his own capital (rather than borrowed capital) for the investment. A means to adjust the rate of return for borrowed capital is discussed in Section IV.

The procedure outlined in this paper simplifies the calculations required to analyze the profitability of switching from high to low pressure. The simplification is accomplished by specifying certain data. The major items of data fixed in this analysis are the way of depreciating the investment, the annual change in energy costs, and the general rate of inflation. Some producers may want to specify the energy price year by year throughout the period instead of assuming a constant rate of increase of either 8 or 11 percent. Others may want to specify annual rates of general inflation instead of assuming a constant average annual rate. If for these or other reasons the assumptions made in the simplified analysis here are considered inappropriate, we recommend that individuals use PVBUDGT, a computerized discounted cash flow procedure to analyze the profitability of an investment. The use of this program is described in User's Guide For PVBUDGT Net Present Value Partial Budgeting[6/].

II. Calculating First-Year Energy Savings[7/]

Respond to the following questions to estimate expected first-year energy savings.

1. What reduction in pounds per square inch (psi) will be achieved by converting to low pressure? ____________psi
2. What are the water horsepower (whp) savings? ________whp
   Multiply the pressure reduction (psi) in #1 by the pumping capacity in gallons per minute (gpm) and divide this quantity by 1715.
   whp = __________ psi x ________ gpm ÷ 1715.
3. What are the brake horsepower (bhp) savings? _______bhp
   Divide the water horsepower savings from #2 by the product of the pump efficiency times the drive efficiency as given in Table 1.
   bhp savings = _____ whp ÷ (_______pump eff. x ______drive eff.)

Table 1.[8/] Pump and drive efficiencies

Item	Efficiency
Centrifugal pump	.70
Turbine pump	.75
Right angle gear or V-belt drive	.95
Direct drive	1.00

4. What is the endgun booster pump's brake horsepower requirement?
   Select the brake horsepower requirement from Table 2.
   ____________________bhp

Table 2. Booster pump brake horsepower requirements[9/]

	Pump size		
	2 Hp	3 Hp	5 Hp
Electric	2	3	5
Diesel generator	3	4	7

5. What are the brake horsepower hour savings? ________ bhp hrs. Subtract the booster pump's brake horsepower requirement in #4 from the brake horsepower savings in #3. Multiply this value by the average number of hours the center pivot operates per year.

   bhp hr. savings = (_____bhp #3 - _____ bhp #4) x ___ hrs. per year

6. What are the annual energy savings? ____ gal. or kwh. Multiply the brake horsepower hour savings from #5 by the number of gallons of fuel or kwh of electricity used per brake horsepower hour (see Table 3).

   annual energy savings = ________ bhp savings x ______ gal. or kwh per bhp hr.

Table 3[10/] Energy consumption per brake horsepower hour

Energy type	Consumption per brake horsepower hour
Gasoline	.082 gal.
LP	.090 gal.
Diesel	.065 gal.
Electricity	.848 kwh

7. What are the annual energy cost savings for the first year?

$________________

Multiply the energy savings in gallons or kwh expected for the first year by the cost per gallon or kwh.

annual energy cost savings = ______ gal. or kwh savings x ______ $/gal. or kwh

As an example assume that Farmer Green plans to convert to low pressure irrigation. He owns an electric center pivot system which operates at 75 psi and wishes to switch to a system utilizing 35 psi. His pressure reduction is 40 psi (item 1). If his system is pumping 900 gallons per minute, then 900 is multiplied by 40 and the product is divided by 1715 (item 2). The resulting water horsepower savings equals 21 whp. Brake horsepower savings (item 3) are calculated by dividing water horsepower savings by the product of the pump efficiency times the drive efficiency. Assuming that Green owns a turbine pump with direct drive, the product is 1 x .75 = .75. The pump and drive efficiencies are taken from Table 1. Then the 21 water horsepower savings divided by .75 yields a brake horsepower savings of 28. Mr. Green feels the endgun needs a 2 horsepower pump to operate properly. He estimates, in item 4, the additional brake horsepower required for the booster pump. The entry in Table 2 indicates 2 brake horsepower are required, making the net brake horsepower savings 28 minus 2 or 26. In item 5 brake horsepower hour savings are calculated. If Green's system operates 1,000 hours annually, his savings would be 26 times 1,000 hours for a total of 26,000 brake horsepower hours per year. In item 6 brake horsepower hour savings are converted to units of energy saved per year. If Green's system operates with electricity, his savings will total 26,000 bhp hours x .848 kwh/bhp hr. = 22,048 kwh.

In item 7 Green's energy cost savings are computed. If electricity cost during the first year is expected to average \$.05 per kwh, then total savings the first year are \$.05 x 22,048 kwh = \$1,102.

III. Computation of the Cost of an Investment in Low Pressure Irrigation

This section provides a form for listing the investment required for conversion to low pressure irrigation.

8.	Nozzles, end gun, booster pump	$__________
9.	Net cost to pull and adjust pumps[11/]	$__________
10.	New motor or power unit modification	$__________
11.	Other investment costs required to convert to low pressure	$__________
12.	Total investment costs (8 + 9 + 10 + 11)	$__________

IV. Comparing Investment Cost with First-Year Energy Savings to Determine the Rate of Return[12/]

The ratio of investment cost to first-year energy cost savings can be used to determine the rate of return on the investment if assumptions are made about the repayment period, annual increases in energy costs, the operator's tax bracket, and the depreciation schedule. The investment-first-year savings ratio is calculated as follows:

$$\text{investment-first-year savings ratio} = \frac{\text{investment cost (line 12)}}{\text{first-year energy cost savings (line 7)}}$$

Table 4 presents the rates of return which correspond to various ratios of investment cost to first-year energy savings for different tax brackets. A five-year repayment schedule is used. Energy costs are assumed to increase at a rate of 8 percent of current costs per year. If the general inflation rate is 8 percent, then real energy costs remain almost constant. The straight-line depreciation method and 10 percent investment credit are also used in calculating the total values. The investment is assumed to be completely depreciated for tax purposes over the five-year period.

Table 4[a/] Ratio of investment cost to expected first-year energy savings for a conversion to low pressure irrigation corresponding to various rates of return and tax brackets with a five-year repayment schedule and assuming annual energy cost increases of 8 percent.

Rate of return[b/] (%)	Marginal income tax bracket (%) .00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00
5	5.57	5.53	5.51	5.50	5.48	5.46	5.44	5.42	5.39
6	5.41	5.34	5.32	5.29	5.27	5.24	5.20	5.17	5.13
7	5.25	5.16	5.13	5.10	5.06	5.03	4.98	4.94	4.89
8	5.10	4.99	4.95	4.92	4.87	4.83	4.78	4.72	4.66
9	4.96	4.83	4.79	4.74	4.70	4.65	4.59	4.53	4.46
10	4.82	4.67	4.63	4.58	4.53	4.47	4.41	4.34	4.27
11	4.69	4.53	4.48	4.43	4.37	4.31	4.24	4.17	4.09
12	4.56	4.39	4.34	4.28	4.22	4.16	4.09	4.01	3.92
13	4.44	4.26	4.20	4.14	4.08	4.01	3.94	3.86	3.77
14	4.33	4.13	4.08	4.01	3.95	3.88	3.80	3.71	3.62
15	4.22	4.01	3.95	3.89	3.82	3.75	3.67	3.58	3.49
16	4.11	3.90	3.84	3.77	3.70	3.63	3.54	3.46	3.36
17	4.01	3.79	3.73	3.66	3.59	3.51	3.43	3.34	3.24
18	3.91	3.69	3.62	3.55	3.48	3.40	3.32	3.23	3.13
19	3.81	3.59	3.52	3.45	3.38	3.30	3.21	3.12	3.02
20	3.72	3.49	3.43	3.35	3.28	3.20	3.11	3.02	2.92
21	3.64	3.40	3.33	3.26	3.19	3.11	3.02	2.93	2.83
22	3.55	3.31	3.25	3.17	3.10	3.02	2.93	2.84	2.74
23	3.47	3.23	3.16	3.09	3.01	2.93	2.85	2.75	2.66
24	3.39	3.15	3.08	3.01	2.93	2.85	2.76	2.67	2.58
25	3.32	3.07	3.00	2.93	2.85	2.77	2.69	2.60	2.50
26	3.24	3.00	2.93	2.86	2.78	2.70	2.61	2.52	2.43
27	3.17	2.93	2.86	2.79	2.71	2.63	2.54	2.45	2.36
28	3.10	2.86	2.79	2.72	2.64	2.56	2.48	2.39	2.29
29	3.04	2.79	2.72	2.65	2.58	2.50	2.41	2.32	2.23
30	2.98	2.73	2.66	2.59	2.51	2.43	2.35	2.26	2.17

a/ This table is based on "Economic Analysis for Improving Irrigation Pumping Plant Efficiencies", J. C. White and R. Kern Stutler, ASAE Paper #80-3039, Utah State University, Logan, June 1980. The table was developed assuming 10 percent investment credit, and 8 percent annual energy cost escalation. If the general inflation rate were 8 percent then real energy costs would remain about the same. The straight line depreciation method was used and the investment depreciated over five years.

b/ In finance literature the rate of return would be referred to as the internal rate of return.

To use the table the operator should first determine the ratio of the investment cost to the expected first-year energy savings. This is done by dividing line 12 by line 7. Then he finds the column which most closely corresponds to his marginal tax bracket. Within the column he determines the number which approximates the ratio of investment cost to expected first-year energy savings for his proposed project. The rate of return is found in the first (left) column of the table. This number represents the nominal rate of return the irrigator can expect to earn on the investment using his own capital. The real rate of return is approximately equal to the nominal rate minus the general inflation rate. If the irrigator wishes to assume that energy costs will rise at a rate of 11 percent per year, Table 5 can be used to find the nominal rate of return. If energy costs rise at a rate of 11 percent annually and the general inflation rate is 8 percent, then real energy costs increase approximately 3 percent per year.

V. Example

Farmer Green wishes to invest in a conversion to low pressure irrigation. He estimates the conversion cost to be \$3,400 and expects first-year energy savings of \$1,102. He is in a 32 percent marginal tax bracket. His question is whether this is an economically feasible investment given a five-year repayment period. Table 4 can be used to provide an answer if 8 percent annual energy cost increases are assumed. First divide the cost by the expected first-year energy savings: \$3,400 ÷ \$1,102 = 3.09. Then check the 32 percent marginal tax bracket column for the number nearest to 3.09. The number 3.09 is close to 3.11 which corresponds to a rate of return of 21 percent. Thus, Farmer Green could expect to earn a nominal annual return of about 21 percent on his capital

Table 5[a/] Ratio of investment cost to expected first-year energy savings for a conversion to low pressure irrigation corresponding to various rates of return and tax brackets with a five-year repayment schedule and assuming annual energy cost increases of 11 percent.

Rate of return[b/] (%)	Marginal income tax bracket (%) .00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00
5	5.90	5.85	5.84	5.82	5.80	5.78	5.76	5.74	5.71
6	5.72	5.65	5.63	5.60	5.57	5.54	5.51	5.47	5.43
7	5.55	5.46	5.43	5.39	5.36	5.32	5.27	5.22	5.17
8	5.39	5.27	5.24	5.20	5.15	5.11	5.05	4.99	4.93
9	5.24	5.10	5.06	5.01	4.96	4.91	4.85	4.78	4.71
10	5.09	4.94	4.89	4.84	4.78	4.72	4.66	4.58	4.50
11	4.95	4.78	4.73	4.67	4.61	4.55	4.48	4.40	4.31
12	4.82	4.63	4.58	4.52	4.45	4.39	4.31	4.23	4.14
13	4.69	4.49	4.43	4.37	4.30	4.23	4.15	4.07	3.97
14	4.56	4.36	4.30	4.23	4.16	4.09	4.00	3.92	3.82
15	4.44	4.23	4.17	4.10	4.03	3.95	3.86	3.77	3.67
16	4.33	4.11	4.04	3.97	3.90	3.82	3.73	3.64	3.54
17	4.22	3.99	3.92	3.85	3.78	3.70	3.61	3.51	3.41
18	4.11	3.88	3.81	3.74	3.66	3.58	3.49	3.40	3.29
19	4.01	3.77	3.70	3.63	3.55	3.47	3.38	3.28	3.18
20	3.91	3.67	3.60	3.53	3.45	3.36	3.27	3.18	3.07
21	3.82	3.57	3.50	3.43	3.35	3.26	3.17	3.08	2.97
22	3.73	3.48	3.41	3.33	3.25	3.17	3.08	2.98	2.88
23	3.64	3.39	3.32	3.24	3.16	3.08	2.99	2.89	2.79
24	3.56	3.30	3.23	3.16	3.08	2.99	2.90	2.80	2.70
25	3.48	3.22	3.15	3.07	2.99	2.91	2.82	2.72	2.62
26	3.40	3.14	3.07	2.99	2.91	2.83	2.74	2.65	2.54
27	3.32	3.07	3.00	2.92	2.84	2.75	2.67	2.57	2.47
28	3.25	2.99	2.92	2.85	2.77	2.68	2.59	2.50	2.40
29	3.18	2.92	2.85	2.78	2.70	2.61	2.53	2.43	2.33
30	3.11	2.86	2.79	2.71	2.63	2.55	2.46	2.37	2.27

a/ This table is based on "Economic Analysis for Improving Irrigation Pumping Plant Efficiencies", J. C. White and R. Kern Stutler, ASAE Paper #80-3039, Utah State University, Logan, June 1980. The table was developed assuming 10% investment credit and 11 percent annual energy cost escalation. If the general inflation rate were 8 percent, then real energy costs would increase at approximately 11 - 8 = 3 percent per year. The straight line depreciation method was used and the investment was depreciated over five years.

b/ In finance literature the rate of return would be referred to as the internal rate of return.

if he went ahead with the conversion. The investment would not represent the best use of his resources if his nominal after-tax earnings on an alternative investment exceed 21 percent. If the general inflation rate is 8 percent, then the real rate of return is approximately 21 - 8 = 13 percent[13/].

The situation is analyzed differently if the farmer has to borrow the funds for the project. Using the previous example, assume Green has to borrow money for the investment at 16 percent interest. The 16 percent nominal interest cost must be converted to an after-tax interest cost. The after-tax interest cost is calculated as follows:

after tax interest rate = nominal interest rate x (1 - marginal tax rate).

If Green's marginal tax rate is 32 percent, his after-tax interest rate is: 16% x (1 - .32) = 10.9%. Based on this result, if Green's nominal rate of return to the irrigation investment is 21 percent, he would increase his net returns by borrowing in order to make the investment because the rate of return exceeds the after-tax interest cost[14/].

Irrigators may wish to consider the direct expensing option which permits up to $5,000 of investment cost to be deducted as a direct expense. Tables 6 and 7 present the rates of return for various ratios of investment cost to first-year energy savings when direct expensing is used to reduce tax payments and either 8 or 11 percent rates of annual energy cost increase are assumed.

As an example assume that Green plans an investment in low pressure irrigation costing $3,400. He expects first-year energy savings of $1,102 and is in a 32 percent marginal tax bracket. The situation is the same as the previous example except now Green will use the direct expensing option to reduce tax payments

Table 6[a/] Ratio of investment cost to expected first-year energy savings for a conversion to low pressure irrigation corresponding to various rates of return and tax brackets using the direct expensing tax option and assuming annual energy cost increases of 8 percent.

Rate of return[b/] (%)	Marginal income tax bracket (%) .00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00
5	5.04	5.00	4.98	4.97	4.95	4.93	4.91	4.89	4.86
6	4.90	4.85	4.83	4.81	4.79	4.77	4.75	4.72	4.69
7	4.76	4.70	4.68	4.66	4.64	4.62	4.59	4.56	4.53
8	4.63	4.57	4.55	4.52	4.50	4.47	4.44	4.41	4.37
9	4.50	4.43	4.41	4.39	4.36	4.34	4.30	4.27	4.23
10	4.38	4.31	4.29	4.26	4.23	4.20	4.17	4.13	4.09
11	4.27	4.19	4.16	4.14	4.11	4.08	4.04	4.00	3.96
12	4.16	4.07	4.05	4.02	3.99	3.96	3.92	3.88	3.83
13	4.05	3.96	3.94	3.91	3.88	3.84	3.80	3.76	3.71
14	3.95	3.86	3.83	3.80	3.77	3.73	3.69	3.65	3.60
15	3.85	3.76	3.73	3.70	3.66	3.63	3.59	3.54	3.49
16	3.76	3.66	3.63	3.60	3.56	3.53	3.49	3.44	3.39
17	3.66	3.57	3.54	3.50	3.47	3.43	3.39	3.34	3.29
18	3.58	3.48	3.45	3.41	3.38	3.34	3.29	3.25	3.19
19	3.49	3.39	3.36	3.33	3.29	3.25	3.21	3.16	3.10
20	3.41	3.31	3.28	3.24	3.20	3.16	3.12	3.07	3.02
21	3.33	3.23	3.20	3.16	3.12	3.08	3.04	2.99	2.93
22	3.26	3.15	3.12	3.08	3.05	3.00	2.96	2.91	2.86
23	3.19	3.08	3.04	3.01	2.97	2.93	2.88	2.83	2.78
24	3.12	3.01	2.97	2.94	2.90	2.86	2.81	2.76	2.71
25	3.05	2.94	2.90	2.87	2.83	2.79	2.74	2.69	2.64
26	2.99	2.87	2.84	2.80	2.76	2.72	2.67	2.62	2.57
27	2.92	2.81	2.77	2.74	2.70	2.66	2.61	2.56	2.50
28	2.86	2.75	2.71	2.68	2.64	2.59	2.55	2.50	2.44
29	2.80	2.69	2.65	2.62	2.58	2.54	2.49	2.44	2.38
30	2.75	2.63	2.60	2.56	2.52	2.48	2.43	2.38	2.33

a/ This table is based on "Economic Analysis for Improving Irrigation Pumping Efficiencies" J. C. White and R. Kern Stutler, ASAE Paper #80-3039, Utah State University, Logan, June 1980. The table was developed assuming the investment is deducted as a direct expense instead of using the investment credit and depreciation options. At present only $5,000 can be deducted in this manner. If the investment exceeds $5,000, some interpolation between this table and Table 4 is needed as the excess of the investment over $5,000 must be deducted in the conventional manner, using depreciation and investment credit.

b/ In finance literature the rate of return would be referred to as the internal rate of return.

Table 7[a/] Ratio of investment cost to expected first-year energy savings for a conversion to low pressure irrigation corresponding to various rates of return and tax brackets using the direct expensing tax option and assuming annual energy cost increases of 11 percent.

Rate of return[b/] (%)	Marginal income tax bracket (%) .00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00
5	5.34	5.29	5.28	5.26	5.24	5.22	5.20	5.17	5.15
6	5.18	5.13	5.11	5.09	5.07	5.05	5.02	4.99	4.96
7	5.04	4.97	4.95	4.93	4.91	4.89	4.86	4.83	4.79
8	4.89	4.83	4.81	4.78	4.76	4.73	4.70	4.66	4.62
9	4.76	4.68	4.66	4.64	4.61	4.58	4.55	4.51	4.47
10	4.63	4.55	4.53	4.50	4.47	4.44	4.40	4.36	4.32
11	4.50	4.42	4.40	4.37	4.34	4.30	4.27	4.23	4.18
12	4.39	4.30	4.27	4.24	4.21	4.17	4.14	4.09	4.04
13	4.27	4.18	4.15	4.12	4.09	4.05	4.01	3.97	3.92
14	4.16	4.07	4.04	4.01	3.97	3.93	3.89	3.85	3.79
15	4.06	3.96	3.93	3.90	3.86	3.82	3.78	3.73	3.68
16	3.95	3.85	3.82	3.79	3.75	3.71	3.67	3.62	3.57
17	3.86	3.75	3.72	3.69	3.65	3.61	3.57	3.52	3.46
18	3.76	3.66	3.63	3.59	3.55	3.51	3.47	3.42	3.36
19	3.67	3.57	3.53	3.50	3.46	3.42	3.37	3.32	3.26
20	3.59	3.48	3.44	3.41	3.37	3.33	3.28	3.23	3.17
21	3.50	3.39	3.36	3.32	3.28	3.24	3.19	3.14	3.08
22	3.42	3.31	3.28	3.24	3.20	3.16	3.11	3.06	3.00
23	3.35	3.23	3.20	3.16	3.12	3.07	3.03	2.97	2.92
24	3.27	3.15	3.12	3.08	3.00	3.00	2.95	2.90	2.84
25	3.20	3.08	3.05	3.01	2.97	2.92	2.88	2.82	2.76
26	3.13	3.01	2.98	2.94	2.90	2.85	2.80	2.75	2.69
27	3.06	2.94	2.91	2.87	2.83	2.78	2.74	2.68	2.62
28	3.00	2.88	2.84	2.80	2.76	2.72	2.67	2.62	2.56
29	2.93	2.81	2.78	2.74	2.70	2.65	2.61	2.55	2.49
30	2.87	2.75	2.72	2.68	2.64	2.59	2.54	2.49	2.43

a/ This table is based on "Economic Analysis for Improving Irrigation Pumping Efficiencies", J. C. White and R. Kern Stutler, ASAE Paper #80-3039, Utah State University, Logan, June 1980. The table was developed assuming the investment is deducted as a direct expense. At present only $5,000 can be deducted in this way. If the investment exceeds $5,000 some interpolation between this table and Table 5 is needed because the excess of the investment over $5,000 must be deducted from taxes using depreciation and investment credit.

b/ In finance literature the rate of return would be referred to as the internal rate of return.

instead of depreciation and investment credit. He assumes that energy costs increase 8 percent per year. The ratio of investment cost to first-year energy savings is: $3,400 ÷ $1,102 = 3.09. Table 6 is used to determine the rate of return corresponding to the ratio of 3.09. Examination of the 32 percent marginal tax rate column reveals that the number 3.09 is closest to 3.08 which corresponds to a rate of return of 21 percent. Thus, when the direct expensing option is used, the investment yields a nominal return of 21 percent which is the same as the return when depreciation and investment credit were used to reduce taxes. If a general inflation rate of 8 percent is assumed, the real rate of return is about 21 - 8 = 13 percent.

Footnotes

1/ Bergsrud, F., "Selecting A Center Pivot", Agricultural Extension Service, University of Minnesota. Extension Folder no. 444-1979.

2/ The worksheet follows the revisions in the tax laws enacted for 1982. It is assumed that Minnesota state income tax laws will be revised to follow the federal guidelines.

3/ This limitation increases to $7,500 in 1984-85, and to $10,000 for 1986 and later years.

4/ The after-tax rate of return to the operator's capital is referred to in the finance literature as the internal rate of return.

5/ 1980 Energy Policy and Conservation Biennial Report, Minnesota Energy Agency, St. Paul, pp. 2-59 and 2-10.

6/ User's Guide for PVBUDGT Net Present Value Partial Budgeting, Earl J. Fuller, and Dale W. Nordquist, no. CDA101G, Department of Agricultural and Applied Economics and Agricultural Extension Service, University of Minnesota, St. Paul, June 1978.

7/ The procedure for calculating energy savings is based on "Water Sources and Irrigation Economics", Development of Irrigation and Specialty Crops, Agricultural Experiment Station, University of Minnesota. Miscellaneous Report 150-1978, pp. 15-21. Energy consumption of various irrigation power units as well as efficiency estimates for selected irrigation components were obtained from D. Eisenhauer and G. Morin, "Pumping Plant Efficiency Tests", ASAE Paper no. 80-2553, University of Nebraska, Lincoln, December 1980.

8/ Eisenhauer, et al.

Footnotes

9/ The table assumes the booster pump operates 100 percent of the time.

10/ Eisenhauer, et al., p. 2. Figures in this table are averages for several power unit models. Individual fuel usage and energy savings may vary from these estimates depending on type of power unit used.

11/ The operator should reduce the cost of pulling and adjusting the pump by the expense of whatever repairs would be required to keep the pump operating at high pressure. The value entered in item 9 should be thought of as the additional cost of making the conversion.

12/ This section and Tables 4, 5, 6, and 7 are based on "Economic Analysis for Improving Irrigation Pumping Plant Efficiencies", J. C. White and R. Kern Stutler, ASAE Paper no. 80-3039, Utah State University, Logan, June 1980.

13/ The net cash flows are in terms of "nominal" or money values. Thus the rate of return r which makes the net present value zero is a nominal rate of return. "Real" values reflect purchasing power of future cash flows in today's terms. The process of converting from nominal to real values uses the standard discounting procedures.

The nominal dollar flows must be discounted by both an inflation rate of f and the real interest rate of return i. In these terms the nominal rate of return r shown in the left column of tables 4, 5, 6 and 7 is related to i and f in the following manner:

$$(1 + r) = (1 + i)(1 + f) = (1 + i + f + if)$$

and a more precise method of solving for the real internal value of return i is:

$$i = \frac{r - f}{1 + f}$$

This more precise method of calculating i can be used in place of the simple subtraction suggested in the text. In the example above, r = .21 and f = .08.

Thus $i = \frac{.21 - .08}{1.08} = .1204$, approximately 1 percent less than the 13% obtained using the simple subtraction suggested in the text.

The subtraction procedure will always overstate the real rate of return for positive inflation rates, with the magnitude of the overestimation increasing as i and f increase. However, for most investments simply subtracting the inflation rate from the nominal rate of return listed in the table yields results as reliable as the data warrant.

14/ Because 100 percent of the investment cost can only be borrowed when an irrigator has other equity to secure the loan, the financing of the conversion requires a combination of debt and equity financing. The cost of capital is composed of a combination of the amount paid for borrowed (debt) capital and the opportunity cost of equity capital. The opportunity cost is what the equity capital could have earned in its best alternative use. These calculations are beyond the scope of this paper, but they are covered by Peter Barry, et al., Financial Management in Agriculture. Interstate Printers and Publishers, Danville, Illinois, Chapter 12, 1979. Because the rate of return on equity capital normally exceeds the cost of borrowed funds, the cost of a combination of borrowed and equity capital is expected to be higher than the interest paid on borrowed funds.